Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims

Claims 1-35 (Cancelled)

36. (Currently Amended) A method of operating a solid oxide regenerative fuel cell, comprising:

operating the solid oxide regenerative fuel cell in a fuel cell mode by providing a fuel to a negative electrode and providing an oxidizer to a positive electrode to generate electricity and water vapor at the negative electrode;

operating the solid oxide regenerative fuel cell in an electrolysis mode by providing electricity to the fuel cell and providing water vapor to the negative electrode to generate fuel at the negative electrode and oxygen at the positive electrode; and

providing a sufficient reducing atmosphere to the negative electrode when the solid oxide regenerative fuel cell operates in the electrolysis mode to prevent the negative electrode from oxidizing, wherein the negative electrode comprises no noble metal or an unavoidable trace impurity amount of noble metal ~~less than 1 mg/cm^2 of noble metal~~.

37. (Original) The method of claim 36, wherein the fuel and the reducing atmosphere comprise hydrogen.

38. (Original) The method of claim 37, wherein the water to hydrogen ratio at the negative electrode during the electrolysis mode is 8 or less.

39. (Original) The method of claim 36, wherein the reducing atmosphere comprises forming gas.

40. (Original) The method of claim 36, wherein the reducing atmosphere comprises carbon monoxide.

41 – 43 (Cancelled).

44. (Currently Amended) The method of claim 36 ~~43~~, wherein:

the positive electrode comprises at least one of LSM, LSCo, LCo, LSF, LSCoF, PSM or a combination thereof with an ionic conducting phase; and

the negative electrode comprises at least one of Ni, Cu, Fe or a combination thereof with an ionic conducting phase.

45. (Original) The method of claim 44, wherein:

the positive electrode consists essentially of LSM; and

the negative electrode consists essentially of a Ni-YSZ cermet.

46. (Original) The method of claim 36, wherein the reducing atmosphere does not chemically participate in the electrolysis process and is cycled through the fuel cell without being consumed.

47. (Original) The method of claim 46, wherein the fuel cell is cycled between the fuel cell mode and the electrolysis mode at least 30 times.

48. (Original) The method of claim 47, further comprising:

generating hydrogen at the negative electrode in the electrolysis mode by electrolysis of water vapor;

providing remaining water vapor and the generated hydrogen to a water-hydrogen separator to separate the hydrogen from water;

providing the separated hydrogen to a compressor;

providing a first portion of the compressed hydrogen to a hydrogen storage vessel; and

providing a second portion of the compressed hydrogen to the negative electrode to maintain the sufficient reducing atmosphere at the negative electrode.

49. (New) A method of operating a solid oxide regenerative fuel cell, comprising:

operating the solid oxide regenerative fuel cell in a fuel cell mode by providing a fuel to a negative electrode and providing an oxidizer to a positive electrode to generate electricity and water vapor at the negative electrode;

operating the solid oxide regenerative fuel cell in an electrolysis mode by providing electricity to the fuel cell and providing water vapor to the negative electrode to generate fuel at the negative electrode and oxygen at the positive electrode; and

providing a sufficient reducing atmosphere to the negative electrode when the solid oxide regenerative fuel cell operates in the electrolysis mode to prevent the negative electrode from oxidizing;

wherein:

the negative electrode comprises less than 1 mg/cm^2 of noble metal; and

the negative electrode comprises at least one of Ni, Cu, Fe or a combination thereof with an ionic conducting phase.

50. (New) The method of claim 49, wherein the fuel and the reducing atmosphere comprise hydrogen.

51. (New) The method of claim 50, wherein the water to hydrogen ratio at the negative electrode during the electrolysis mode is 8 or less.

52. (New) The method of claim 49, wherein the reducing atmosphere comprises forming gas.

53. (New) The method of claim 49, wherein the reducing atmosphere comprises carbon monoxide.

54. (New) The method of claim 49, wherein the negative electrode comprises less than 20 weight percent of noble metal.

55. (New) The method of claim 54, wherein the negative electrode comprises less than 0.1 mg/cm^2 of noble metal and less than 1 weight percent of noble metal.

56. (New) The method of claim 55, wherein the negative electrode comprises no noble metal or an unavoidable trace impurity amount of noble metal.

57. (New) The method of claim 56, wherein the positive electrode comprises at least one of LSM, LSCo, LCo, LSF, LSCoF, PSM or a combination thereof with an ionic conducting phase.

58. (New) The method of claim 57, wherein:

the positive electrode consists essentially of LSM; and

the negative electrode consists essentially of a Ni-YSZ cermet.

59. (New) The method of claim 49, wherein the reducing atmosphere does not chemically participate in the electrolysis process and is cycled through the fuel cell without being consumed.

60. (New) The method of claim 59, wherein the fuel cell is cycled between the fuel cell mode and the electrolysis mode at least 30 times.

61. (New) The method of claim 60, further comprising:

generating hydrogen at the negative electrode in the electrolysis mode by electrolysis of water vapor;

providing remaining water vapor and the generated hydrogen to a water-hydrogen separator to separate the hydrogen from water;

providing the separated hydrogen to a compressor;

providing a first portion of the compressed hydrogen to a hydrogen storage vessel; and

providing a second portion of the compressed hydrogen to the negative electrode to maintain the sufficient reducing atmosphere at the negative electrode.

62. (New) A method of operating a solid oxide regenerative fuel cell, comprising:

operating the solid oxide regenerative fuel cell in a fuel cell mode by providing a fuel to a negative electrode and providing an oxidizer to a positive electrode to generate electricity and water vapor at the negative electrode;

operating the solid oxide regenerative fuel cell in an electrolysis mode by providing electricity to the fuel cell and providing water vapor to the negative electrode to generate fuel at the negative electrode and oxygen at the positive electrode;

providing a sufficient reducing atmosphere to the negative electrode when the solid oxide regenerative fuel cell operates in the electrolysis mode to prevent the negative electrode from oxidizing, wherein the negative electrode comprises less than 1 mg/cm^2 of noble metal;

generating hydrogen at the negative electrode in the electrolysis mode by electrolysis of water vapor;

providing remaining water vapor and the generated hydrogen to a water-hydrogen separator to separate the hydrogen from water;

providing the separated hydrogen to a compressor;

providing a first portion of the compressed hydrogen to a hydrogen storage vessel; and

providing a second portion of the compressed hydrogen to the negative electrode to maintain the sufficient reducing atmosphere at the negative electrode.

63. (New) The method of claim 62, wherein the fuel and the reducing atmosphere comprise hydrogen.

64. (New) The method of claim 63, wherein the water to hydrogen ratio at the negative electrode during the electrolysis mode is 8 or less.

65. (New) The method of claim 62, wherein the reducing atmosphere comprises forming gas.

66. (New) The method of claim 62, wherein the reducing atmosphere comprises carbon monoxide.

67. (New) The method of claim 62, wherein the negative electrode comprises less than 20 weight percent of noble metal.

68. (New) The method of claim 67, wherein the negative electrode comprises less than 0.1 mg/cm^2 of noble metal and less than 1 weight percent of noble metal.

69. (New) The method of claim 68, wherein the negative electrode comprises no noble metal or an unavoidable trace impurity amount of noble metal.

70. (New) The method of claim 69, wherein:

the positive electrode comprises at least one of LSM, LSCo, LCo, LSF, LSCoF, PSM or a combination thereof with an ionic conducting phase; and

the negative electrode comprises at least one of Ni, Cu, Fe or a combination thereof with an ionic conducting phase.

71. (New) The method of claim 70, wherein:

the positive electrode consists essentially of LSM; and

the negative electrode consists essentially of a Ni-YSZ cermet.

72. (New) The method of claim 62, wherein the reducing atmosphere does not chemically participate in the electrolysis process and is cycled through the fuel cell without being consumed.

73. (New) The method of claim 72, wherein the fuel cell is cycled between the fuel cell mode and the electrolysis mode at least 30 times.